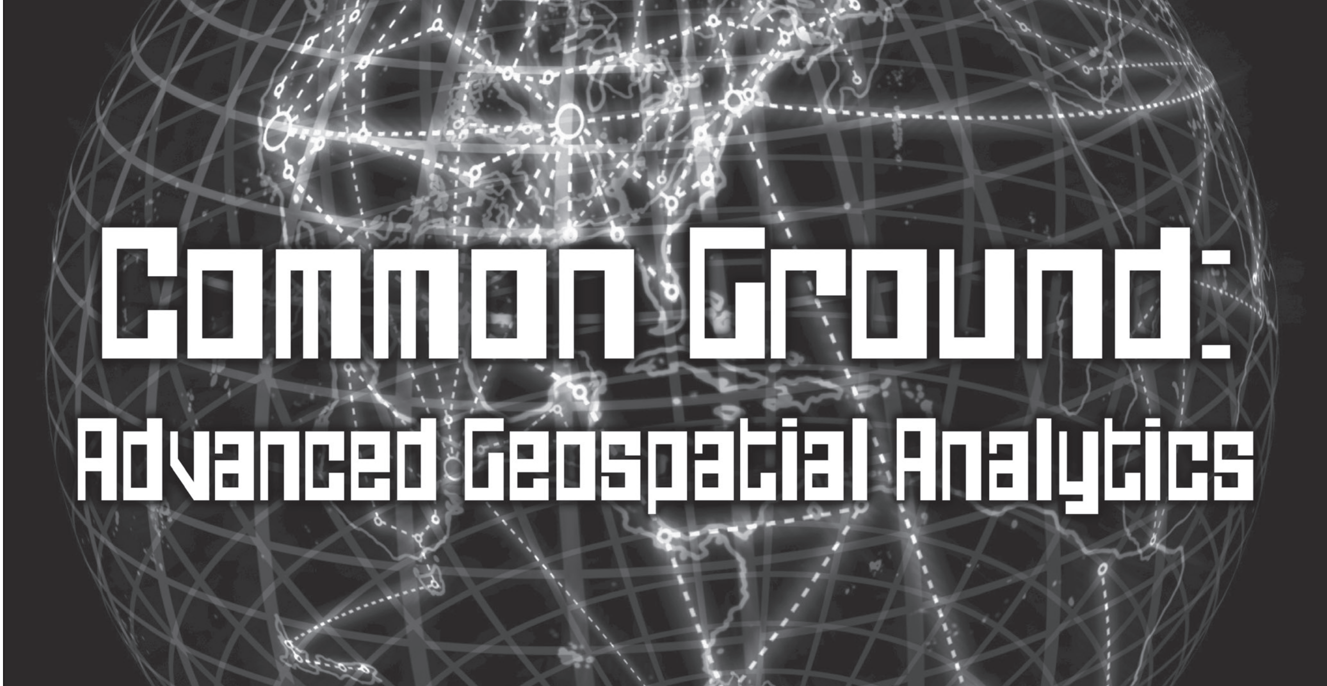

Common Ground: Advanced Geospatial Analytics

By Major Christopher I. Eastburg

It seems that mobile device applications exist for nearly everything now. The genius behind application development is in reducing a complex action to essential information. Geospatial terrain reasoning for military operations will transfer into mobile devices down to the platform level via a National Geospatial-Intelligence Agency program known as the *Commercial Joint Mapping Toolkit (CJMTK)*.

The Army Geospatial Center at Alexandria, Virginia, is the technical manager for a joint capabilities technology demonstration called *Common Ground* (*CG*). A joint technology demonstration is a program that the Office of the Secretary of Defense uses to manage technological solutions and concepts within a 2- to 3-year time frame. Participants in CG include representatives from government, academia, industry, and the military.

The CJMTK integrates the best geospatial tools of government, academia, industry, and the military into a single architecture that is made available for programs of record. Geospatial tools continue to evolve at a breakneck pace. The National Geospatial-Intelligence Agency absorbs about 500 terabytes of data monthly. Computer processing times keep improving; the volume of data keeps increasing; software keeps growing in capability and complexity; the Army keeps getting more networked; and military organizations keep becoming more joint and multinational, involving more Department of Defense and other federal agencies.

Management of the common operational picture continues to evolve with technology. First, there was the analog common operational picture, consisting of hard copy maps mounted on a standard tactical operations center board. Next, stand-alone computers were added to augment the tactical operations center board. The state of the art today consists of stand-alone systems connected to a local area network. As network capabilities increase, mission command systems will continue to move toward a more service-oriented architecture. CJMTK facilitates the ability of algorithms to uncover relevant geospatial products "hidden" in terabytes of data and transfer the necessary information to the platform level.

Early in Operation Iraqi Freedom, the Army did not have geospatial technicians below the division level in the legacy divisions (although the Force XXI divisions did). Resourced only with the Digital Topographic Support System, a chief warrant officer two, and several well-trained Soldiers, it was not possible for the division terrain team to leverage its capabilities across the entire division. As with the Force XXI model, terrain teams were pushed to the brigade combat team level. The best tools for terrain analysis and collaboration should not stop with a headquarters staff. Company commanders and battalion staffs should be able to bring the best tools to their fight since intelligence gathering is predominately a bottom-up endeavor in counterinsurgency operations. Many company commanders, particularly of maneuver units, create a company intelligence support team that is not on the modified table of organization and equipment so that it can generate, manage, and analyze human and geospatial information.

Common Ground and Advanced Geospatial Analytics

CG seeks to move geospatial capabilities further into the realm of command and control. The objective of the architecture and resulting software is a shared understanding (doctrine; geospatial information; and tactics, techniques, and procedures) among American, North Atlantic Treaty Organization, and coalition nation forces. To understand CG, the architecture must be divided into four dimensions:

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- ***Tactical spatial objects (TSOs).*** Analytical, geospatial objects extracted from terrain feature data and described in tactical terms that directly support the planning and execution of military operations.
- ***Engineered knowledge.*** A database of tasks and capabilities by unit, echelon, service, and nation. It can be seen as the intersection of an Army Training and Evaluation Program exercise, doctrine, and a Wikipedia®-like database.
- ***Digital orders.*** The Army performs a lot of analog planning using digital systems. Although collaborative techniques are improving with the use of SharePoint™ and formal knowledge management programs, Army systems will increasingly communicate with digital planning objects instead of e-mail.
- ***CJMTK.*** This tool facilitates a discovery and dissemination service that will find the appropriate geospatial data and then push the relevant tools to the user. For example, a Soldier using a smartphone application would be able to search through 100 terabytes of data, but only receive the information needed for the problem at hand.

Each of the four dimensions is relevant to increasing the efficiency of the military decisionmaking process and current operations, particularly in joint and coalition environments. The rest of this article focuses primarily on TSOs and their utility for mission command in geospatially complex environments such as Afghanistan. One might also think of TSOs as a combination of automated feature extraction algorithms and advanced geospatial decision support tools.

Battlespace Training Reasoning and Awareness–Battle Command is a project that focuses on developing software algorithms that capture integrated terrain and weather effects to provide predictive analysis tools. These tools are essentially automated geospatial "staff estimates." Their ultimate objective is to empower commanders, staffs, and Soldiers by providing them with processed information that allows them to understand and incorporate quicker geospatial reasoning into all processes. The purpose of the TSO is not to replace humans with automation in regard to the geospatial dimension of mission command, but to allow commanders to evaluate geospatial variables more quickly.

TSOs are extracted from vector terrain feature data such as the U.S. Army's theater geospatial databases, from digital elevation models such as digital terrain elevation data, and from digital surface models derived from light detection and ranging technology. The terrain features are grouped, optimized, and analyzed to provide commanders and staffs with responsive terrain information, expressed in warfighter terms tailored to the mission and tasks. While TSOs may be produced by a variety of means, the general idea is to develop automated algorithms and request processes. These algorithms are capable of processing large amounts of terrain data in a rapid, consistent, and standardized manner.

Geospatial data exists in huge quantities that require well-designed processes and tools to give the end user not only data, but also the ability to convert the data to information, to knowledge and, finally, to understanding. Contextual knowledge of geospatial products is essential for human or automated analysis. With the rapid production and dissemination of such tailored knowledge products, commanders and staffs can apply judgment much more quickly throughout all phases of the decisionmaking process and develop a thorough understanding of their operational situation.

"Foundational" TSOs are computed where there is a topographic expert with the massive data storage and analysis power to do comprehensive geospatial processing. Precursor products accomplish extensive computation up front to save time during the decisionmaking and execution processes. Traditional military aspects of terrain products are those commonly associated with the military aspects of terrain, or OAKOC (observation and fields of fire, avenues of approach, key terrain, obstacles, and cover and concealment). These products include, but are not limited to—

- Area obstacles.
- Choke points.
- Concealment.
- Cross-country mobility.
- Fields of fire.
- Linear water obstacles.
- Linear land obstacles.
- Mobility corridors.
- Road networks.

An example of output for area obstacles is shown in Figure 1, page 18. Terrain is categorized as water, forest, steep slope, built-up area, marsh, or depression. It is important to note here that some TSOs (such as cross-country mobility, mobility corridors, and choke points) contain vehicle type and unit size as parameters in their legends. They are still classified as foundational since computation does not require additional mission-specific information.

Mission-specific TSOs include additional tactical information and the foundational terrain data. They are products suitable for a specific force or for multiple force types to perform well-defined military tasks consistent with a mission or objective. For example, routing algorithms require vehicle type and sector sketches require maximum effective ranges. Mission-specific TSOs can be further refined by the current situation through association to command, control, and intelligence information or by evaluation in the context of operational overlays. These products include, but are not limited to—

- Attack positions.
- Command post selection.

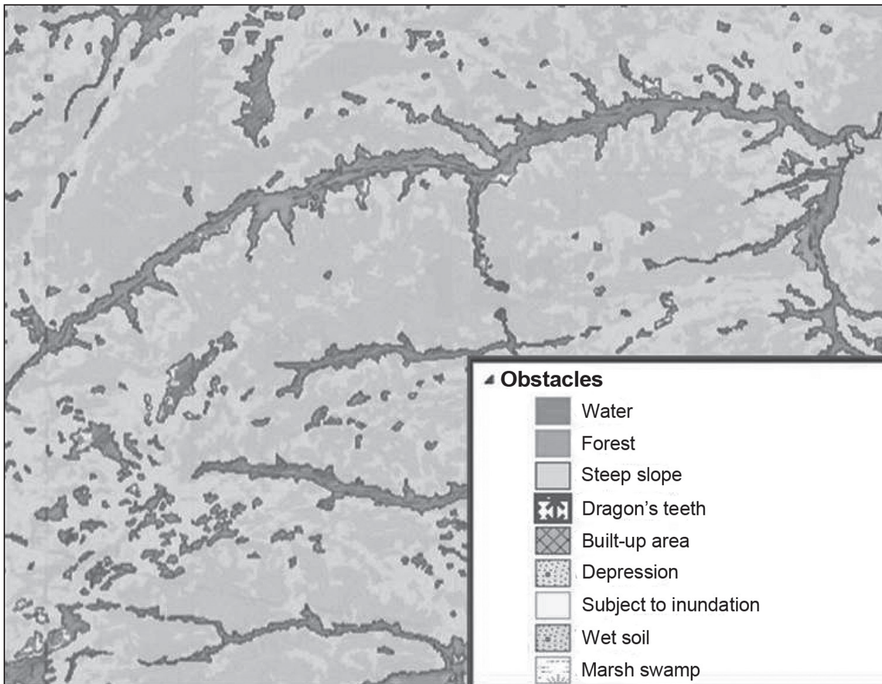

Figure 1. Area obstacles

- Direct fire (battle) positions.
- Helicopter landing zones (HLZs).
- Indirect fire positions.
- Line-of-sight analysis.
- Maneuver route vulnerability.
- River crossing.
- Route analysis—omnidirectional and point to point.

An example of output for two TSOs is shown in Figures 2 and 3. Omnidirectional route analysis defines regions that a vehicle could reach in time intervals such as 5, 10, or 15 minutes. The HLZ function screens terrain for feasible landing zones and returns the size of the landing zone as well as the upslope. There are three types of output for foundational and mission-specific TSOs:

- Graphic control measure (route).
- Traditional overlay (linear obstacles or cross-country mobility).
- Tactical decision aid (sector sketch, maneuver route vulnerability, HLZ).

Potential Applications

Terrain analysis is not simply a geospatial engineer team responsibility. Basic geospatial tools should be pushed down to the lowest useful level. Every Soldier should be able to perform basic terrain analysis, which is simply an updated definition of map reading, but with digital tools and data. As increased technology enables general access to geospatial understanding, geospatial engineer teams will naturally shift to more effort on data quality, software, hardware, data storage, and training, as well as terrain analysis for niche products to support command priorities. Staff sections and subordinate commands should not have to task the geospatial engineer to leverage basic terrain analysis products.

It follows that advanced geospatial analytics should be included in software used in the engineer basic and career courses and other branches. Placing TSOs relevant to the Army Battle Command System software would also improve geospatial decisionmaking. Although it is the standard for real-time collaboration and common operational picture management, Command Post of the Future is geospatially deficient. Command Post of the Future is now CJMTK-compliant, which means that better geospatial analytics are within reach. These tool kits would facilitate real-time geospatial problem solving and improved deliberate planning. Although not very useful in Iraq, the HLZ screening algorithms could help identify potential landing zones for casualty evacuation in real time in remote Afghanistan. The omnidirectional route analysis could tell the Command Post of the Future operator how far insurgents could move a captured U.S. Soldier within 30 minutes, which would be very useful for the identification of traffic control points while forming a hasty cordon. The Tactical Ground Reporting System is the primary system used for patrol planning at the platoon and company level. Company level leaders should have geospatial intelligence in the same software used for patrol planning. The route planning tools available within CJMTK are particularly applicable to the Tactical Ground Reporting System. Route planners should be able to see historical threat information, such as improvised explosive device blast sites and geospatial analysis, with the same software.

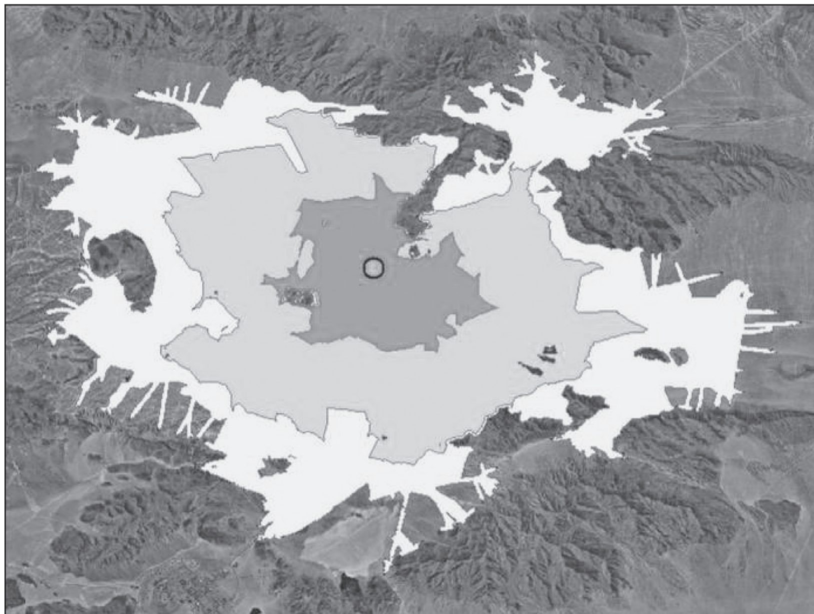

Figure 2. Omnidirectional route analysis

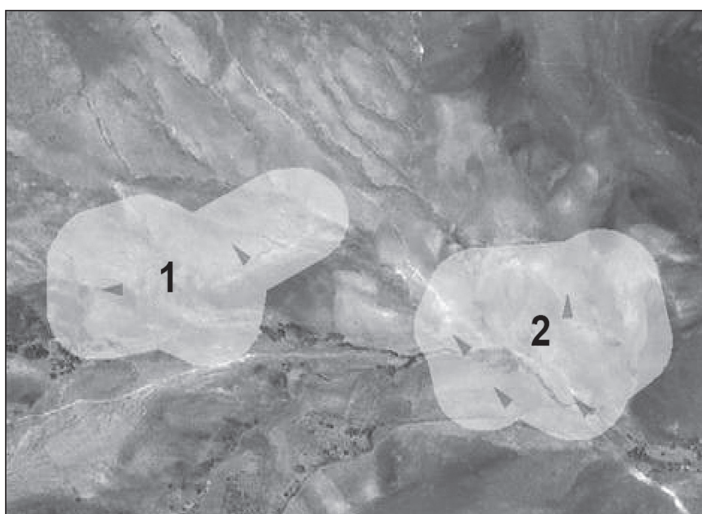

Figure 3. HLZ screening

Conclusion

The combination of networks with high data storage and computational capabilities has opened the door for greater access to geospatial tools for all Soldiers. The Common Ground Joint Capability Technology Demonstration is bigger than just improved geospatial reasoning, but seeks to improve interoperability vertically and horizontally across the Department of Defense, supporting government agencies, and allies. By using the best of government and industry architecture, the CJMTK program will provide the necessary linkage to transition geospatial information into user platforms. Through thoughtful analysis, high-value TSOs should be selected for inclusion into geospatial platforms and selected software applications across the Army.

Geospatial analytics support the military planning and intelligence processes by providing context to the visualization and understanding of the battlefield and conducting mission analysis and course-of-action development. No level of automation can replace human judgment. These geospatial tools simply allow commanders and staffs to understand the battlefield faster and, therefore, will increase decision space.

Major Eastburg is an analyst in the Operations Research Center at the U.S. Military Academy at West Point, New York, and recently crossed over from the Engineer Branch to operations research/systems analysis. He holds master's degrees from the University of Missouri–Rolla (now Missouri University of Science and Technology) and the Georgia Institute of Technology.